# XXI. *An Account of ſome Experiments on the Loſs of Weight in Bodies on being melted or heated. In a Letter from* George Fordyce, *M.D. F.R.S. to Sir* Joſeph Banks, *Bart. P.R.S.*

Read April 28, 1785.

SIR,

ALTHOUGH I have made many experiments on the ſubject of the loſs of weight in bodies on being melted, or heated, I do not think it worth while to lay them all before the Society, as there has not appeared any circumſtance of contradiction in them. I ſhall content myſelf with relating the following one, which appears to me concluſive in determining the loſs of weight in ice when thawed into water, and ſubject to the leaſt fallacy of any I have hitherto made, in ſhewing the loſs of weight in ice on being heated.

The beam I made uſe of was ſo adjuſted as that, with a weight between four and five ounces in each ſcale, $\frac{1}{1000}$ part of a grain made a difference of one diviſion on the index. It was placed in a room, the heat of which was 37 degrees of FAHRENHEIT's thermometer, between one and two in the afternoon, and left till the whole apparatus and the braſs weights acquired the ſame temperature.

A glaſs globe, of three inches diameter nearly, with an indentation at the bottom, and a tube at the top, weighing about 451 grains, had about 1700 grains of *New-River* water poured into it, and was hermetically ſealed, ſo that the

whole, when perfectly clean, weighed 2150$\frac{11}{12}$ of a grain exactly; the heat being brought to 32 degrees, by placing it in a cooling mixture of ſalt and ice till it juſt began to freeze, and ſhaking the whole together.

After it was weighed it was again put into the freezing mixture, and let ſtand for about twenty minutes; it was then taken out of the mixture; part of the water was found to be frozen; and it was carefully wiped, firſt with a dry linen cloth, and afterwards with dry waſhed leather; and on putting it into the ſcale it was found to have gained about the $\frac{1}{600}$ part of a grain. This was repeated five times: at each time more of the water was frozen, and more weight gained. In the mean time the heat of the room and apparatus had ſunk to the freezing point.

When the whole was frozen, it was carefully wiped and weighed, and found to have gained $\frac{3}{1600}$ of a grain and four diviſions of the index. Upon ſtanding in the ſcale for about a minute, I found it began to loſe weight, on which I immediately took it out, and placed it at a diſtance from the beam. I alſo immediately plunged a thermometer in the freezing mixture, and found the temperature 10 degrees; and on putting the ball of the thermometer in the hollow at the bottom of the glaſs veſſel, it ſhewed 12 degrees. I left the whole for half an hour, and found the thermometer, applied to the hollow of the glaſs, at 32°. Every thing now being at the ſame temperature, I weighed the glaſs containing the ice, after wiping it carefully, and found it had loſt $\frac{1}{8}$ and five diviſions; ſo that it weighed $\frac{1}{1600}$, all but one diviſion, more than when the water was fluid.

I now melted the ice, excepting a very ſmall quantity, and left the glaſs veſſel expoſed to the air in the temperature of 32 degrees.

degrees for a quarter of an hour; the little bit of ice continued nearly the ſame. I now weighed it, after carefully wiping the glaſs, and found it heavier than the water was at firſt one diviſion of the beam. Laſtly, I took out the weights, and found the beam exactly balanced as before the experiment.

The acquiſition of weight found on water's being converted into ice, may ariſe from an increaſe of the attraction of gravitation of the matter of the water; or from ſome ſubſtance imbibed through the glaſs, which is neceſſary to render the water ſolid.

Which of theſe poſitions is true may be determined, by forming a pendulum of water, and another of ice, of the ſame length, and in every other reſpect ſimilar, and making them ſwing equal arcs. If they mark equal times, then certainly there is ſome matter added to the water. If the pendulum of ice is quicker in its vibrations, then the attraction of gravitation is increaſed. For there is no poſition more certain, than that a ſingle particle of inanimate matter is perfectly incapable of putting itſelf in motion, or bringing itſelf to reſt; and therefore, that a certain force applied to any maſs of matter, ſo as to give it a certain velocity, will give half the quantity of matter double the velocity, and twice the quantity, half the velocity; and, generally, a velocity exactly in the inverſe proportion to the quantity of matter. Now, if there be the ſame quantity of matter in water as there is in ice, and if the force of gravity in water be $\frac{1}{28000}$ part leſs than in ice, and the pendulum of ice ſwing ſeconds, the pendulum of water will loſe $\frac{1}{28000}$ of a ſecond in each vibration, or one ſecond in 28000, which is almoſt three ſeconds a day, a quantity eaſily meaſured.

I ſhall juſt take notice of an opinion which has been adopted by ſome, that there is matter abſolutely light, or which repels inſtead of attracting other matter. I confeſs this appears abſurd to me; but the following experiment would prove or diſprove it. Suppoſing, for inſtance, that heat was a body, and abſolutely light, and that ice gained weight by loſing heat; then a pendulum of ice would ſwing through the ſame arc in $\frac{1}{1000}$ leſs time than a ſimilar pendulum of water; for the ſame power would not only act upon a leſs quantity of matter, but a counter-acting force would alſo be taken away.

Till the experiment of the pendulum can be made, or ſome other equally certain be ſuggeſted and made, it would be waſting time to enter into conjecture about the cauſe of the gain of weight in the converſion of water into ice in a glaſs veſſel hermetically ſealed.

I ſhall only obſerve, that heat certainly diminiſhes the attractions of coheſion, chemiſtry, magnetiſm, and electricity; and if it ſhould alſo turn out, that it diminiſhes the attraction of gravitation, I ſhould not heſitate to conſider heat as the quality of diminution of attraction, which would in that caſe account for all its effects.

We come, in the next place, to take notice of the ſecond part of the experiment, *viz.* that the ice gained an eighth part of a grain on being cooled to 12 degrees of FAHRENHEIT's thermometer. In this caſe, a variation may ariſe from the contraction of the glaſs veſſel, and conſequent increaſe of ſpecific gravity in proportion to the air. But it is unneceſſary to obſerve, that this would be ſo very ſmall a quantity as not to be obſervable upon a beam adjuſted only to the degree of ſenſibility with which this experiment was tried. In the ſecond place, the air cooled by the ice above the ſcale becoming heavier than

the ſurrounding atmoſphere, would preſs upon the ſcale downward with the whole force of the difference. If a little more than half a pint of air was cooled over the ſcale to the heat of the ice and glaſs containing it, that is, twenty degrees below the freezing point, the difference, according to General Roy's table, would have been the eighth part of a grain, which was the weight acquired; but the air within half an inch of the glaſs veſſel being only one degree below the freezing point, I cannot conceive, that even an eighth part of a pint of air could be cooled over the ſcale to twenty degrees below the freezing point; nor that the whole difference of the weight of the air over the ſcale could ever amount to the 32d of a grain. I have, however, contrived an apparatus which is executing, in which this cauſe of fallacy will be totally removed. I ſhall, therefore, reſt at preſent the ſtate of this part of the ſubject; and leave it only proved, that water gains weight on being frozen.

I am, &c.

G. FORDYCE.